a mass of indifferent tissue, into which pass representatives of all three germinal layers. This must represent the primitive streak.

The persistence of the blastopore to form the anus has been demonstrated in the Amphibia, by Miss Johnson in the Newt, by Gasser in Alytes, and by Spencer in the Frog. The fact that it persists in the Cyclostomata appears to point to the fact that this is a primitive feature retained in those eggs which have not become much modified by the presence of a large mass of yolk. This view would be greatly confirmed if renewed observation on the development of Amphioxus should demonstrate the same fact.

III. "Researches on Myohæmatin and the Histohæmatins." By C. A. MacMunn, M.A., M.D. Communicated by Professor M. Foster, Sec. R.S. Received October 19, 1885.

(Abstract.)

This paper contains an account of observations made on the spectra of the organs and tissues of invertebrates and vertebrates, which have brought to light the presence of a series of animal colouring matters which had not previously been discovered.

The name histohæmatins is proposed for all these colouring matters, and that of myohæmatin for the intrinsic pigment occurring in striped muscle, which belongs to the same series.

These pigments are not identical with any known decomposition product of hæmoglobin, and they are found in animals in whose bodies no hæmoglobin can be found.

The method of examination is as follows:—The tissue or part of organ to be examined is put into a compressorium, by means of which any required thickness can be obtained, it is illuminated by means of a large sub-stage condenser, and examined with a Sorby's microspectroscope fitted to a binocular microscope, the binocular form being preferred, as one tube is free for the observation of the specimen. The source of illumination was generally an argand gas burner, sometimes direct sunlight, sometimes a Swan lamp. The objectives of the microscope up to the one-eighth were so adapted as to enable both fields of the microscope to be fully illuminated, which is a matter of importance in dealing with small quantities of material, or in differentiating those portions of an object which give different spectra.

*The Histohæmatins.*—Examined in this way the organs and tissues of invertebrates and vertebrates present a series of spectra, which are all evidently connected with each other. From Echinoderms to man the same appearances have been found; thus there is a most striking

likeness between the spectra of such organs as the ovaries of a star-fish and the pancreas, stomach-wall, kidney, and other organs of a cat, and between these and that of striped muscle throughout the whole animal kingdom.

To give an idea of the character of these spectra and their distribution is not easy in an abstract, but in general they may be said to consist of at least three bands—one before D, one or two between D and E, and sometimes one or two others nearer violet. When one band occurs between D and E it replaces the two found in other cases, which are of great narrowness compared with other physiological spectra. The band before D is always the same both in the histohæmatins, and in myohæmatin with few exceptions. Sometimes this kind of spectrum is replaced by another in which two narrow bands like those of reduced hæmatin occur nearer the violet than the bands of the latter. It was proved repeatedly that the *banded* spectrum belongs to the deoxidised condition, and the *bandless* to the fully oxidised; accordingly these pigments are respiratory.

Among animals in which I have found these spectra a few may be enumerated with the organs in which they occur. Thus in Echinoderms the *ovaries*, *stomach-wall*, and other parts of *Uraster rubens* show them well marked.

In molluscs, *Limax flavus*, *L. variegatus*, *Arion ater*, *Helix aspersa*, *H. pomatia*, and other slugs and snails contain them in such parts as the *nephridium*, *albumen gland*, *ovo-testis*, *receptaculum seminis*, *foot*, *wall of crop*, *oviduct*, *penis* and *elsewhere*, and all contain myohæmatin in the muscle of the heart in both auricle and ventricle, also in the pharyngeal muscle. In these species, as Dr. Sorby first showed, the bile contains a kind of hæmatin, which is evidently connected with the histohæmatins for reasons given in the complete paper. In other molluscs such as *Littorina littorea*, *Purpura lapillus*, *Trochus cinerarius* and *ziziphinus*, *Patella vulgata*, *Limnæus stagnalis*, *Mytilus edulis*, *Ostraea edulis*, *Anodonta cygnea*, and others, they have been observed by the above method of examination.

In *Arthropods*, such as *Homarus vulgaris*, *Astacus fluviatilis*, *Cancer pagurus*, *Carcinus moenas*, and *Pagurus Bernhardus*, they have also been found, in such situations as the *green glands* (of the two first), the *stomach-wall*, *liver*, exceptionally in the *branchiæ*, and elsewhere. They are also present in insects and in spiders.

In all these invertebrates (and others) they can be studied uninfluenced by the presence of hæmoglobin. Wherever they are seen the corresponding tissue or organ is more or less yellow or reddish-yellow, but sometimes almost colourless.

On examining vertebrates I was surprised to find the same spectra in such situations as the *liver*, *spleen*, *kidney*, *stomach-wall*, *pancreas*, *wall of intestine*, and sometimes in the *ovary*. And by washing out

the blood-vessels with salt solution, I found the bands became much better marked.

Thus:—In fishes they have been observed in the tench, herring, roach, eel, and others.

In reptiles, in *Tropidonotus natrix*, *Bascanium constrictor*, *Scincus officinalis*, *Trionyx*, *Emys Europæa*, *Lacerta viridis*, and *Lacerta agilis*.

In Amphibians, in *Rana temporaria*, *Hyla arborea*, *Bufo vulgaris*, *Salamandra maculosa*, *Siredon pisciformis*, and others.

In *birds*, *e.g.*, *pigeon*, *owl*, *turkey*, *goose*, *duck*, *swift*, &c. The *gizzard* of birds is, however, mainly coloured by oxyhæmoglobin.

In *Mammals*, *e.g.*, *dog*, *cat*, *rat*, *rabbit*, *guinea-pig*, *hedgehog*, *sheep*, *ox*, *pig*, *mouse*, and *man*, as well as in others.

In all cases oxidation and reduction could be brought about. When the bands are invisible they can be brought into view by dipping the portion of organ or tissue into Stokes's fluid, or into a weak solution of ammonium sulphide in water; on exposure to the air they become faint.

*Myohæmatin.*—All the species enumerated and others have been examined for *myohæmatin*, and in all those which possess striped muscle it has been found.

Thus in molluscs, it is found in the heart and pharyngeal muscle of *Limax*, *Arion*, *Helix*, and other pulmonates.

In *Arthropods*, in the cardiac muscle of *Homarus*, *Astacus*, *Cancer*, *Carcinus*, and *Pagurus*, and not in their voluntary muscles (so far); also in the muscle of the cephalo-thorax of such spiders as *Epeira diadema*, *Tegenaria civilis* (and others).

In *insects* it is abundantly present, especially in the muscles from the thorax. It is best marked in those which move the wings actively, such as diurnal and nocturnal lepidopters. So far it has been found in the following insects:—*Musca vomitoria*, *domestica*, and *chlora*, *Apis mellifica*, *Bombus terrestris*, *Vespa vulgaris*, *Hydrophilus*, *Dyticus marginalis*, *Geotrupes stercorarius*, *Lucanus cervus*, *Coccinella*, *Staphylinus olens*, *Cerambyx moschatus*, *Creophilus maxillosus*, *Carabus violaceus*, *Periplaneta orientalis*, *Gryllus domesticus*, *Acrida viridissima*, *Tipula oleracea*, *Pieris rapae*, and various other lepidopters and dipters. It has also been found in the mouth parts of larvæ.

Among vertebrates it has been found in the heart and voluntary muscle of all the fishes, reptiles, amphibians, birds, and mammals enumerated above. It is frequently accompanied by hæmoglobin in these classes, and sometimes replaced by it. It may be apparently absent, but its bands may be brought into view by the use of reducing agents.

The spectrum of myohæmatin is remarkable for the sharpness and narrowness of its bands, in which point it and the other histohæmatins differ from any other known animal pigment. Three bands are

always present, one between C and D, close to D, which corresponds to the first band of the histohæmatin spectrum, two very narrow and sharp, of which the second is darker than the first between D and E; besides these there are one or two nearer violet, one covering E and *b*, the other before F, which are not always present. The 2nd and 3rd bands correspond closely to similar bands in the histohæmatin spectrum, in which they may appear joined to form one broad band.

The colour of the pigment giving this spectrum is yellow or reddish-yellow, but even in very pale muscles the bands can sometimes be seen, especially after the use of a reducing agent.

Various attempts have been made to isolate myohæmatin, but owing to the coloured constituent being joined to a proteid, it will not go into any of the usual solvents. It has been proved by pressing out the plasma from frozen muscle that some of the myohæmatin belongs to the plasma, but even after this treatment, its bands are seen better marked in the muscle than before. It has also been got from blood-free muscle by digesting in pepsin solution, which, however, alters the pigment, as it no longer gives the original spectrum, but another which is remarkable, as it is imitated closely by a spectrum sometimes seen in insect muscle without any treatment. Obtained by this method, the pigment is of a yellow colour, and is only soluble in water.

From the changes which the histohæmatins and myohæmatin undergo with oxidising and reducing agents, and for reasons given in detail in the paper, I have come to the conclusion that these pigments are concerned in the *internal* respiration of the tissues and organs in which they are found.

*Spectrum of the Adrenals.*—Another point of interest brought to light by these observations is the occurrence of hæmochromogen in the medulla of the supra-renal glands of mammals; thus in this situation in man, dog, cat, ox, sheep, pig, guinea-pig, rabbit, and rat, I have found hæmochromogen, the bands of which are very dark; and it would appear that this hæmochromogen is partially removed by washing out the blood-vessels with salt solution. Hence, and owing to the fact that elsewhere it is excretory, as in the bile, the hæmochromogen of the adrenals appears to be excretory; if so a downward metamorphosis of hæmoglobin, and probably (for reasons given in the paper) of the histohæmatins, is one of their functions. Hence if by disease, or by artificial removal, this metabolism is prevented, the incompletely metabolised pigments circulate in the blood, and staining of skin and mucous membrane, as in Addison's disease, may take place. In the urine of Addison's disease such an imperfect metabolite occurs as I have already shown.*

* "Journal of Physiology," vol. vi, p. 37.

To give an idea of the connexion which exists between the histohæmatins and myohæmatin, I have here added a few wave-length measurements. These are given in greater detail in the complete paper, and the spectra have been mapped to the number of 70 in the accompanying charts.

No. 1. A histohæmatin spectrum from the ovaries of a star-fish (*Uraster rubens*) :—

| | |
|---|---|
| 1st Band..... | λ613—593 |
| 2nd „ ..... | λ569—560 |
| 3rd „ ..... | λ556—548·5 |

No. 2. A histohæmatin spectrum from the stomach-wall of a cat :—

| | |
|---|---|
| 1st Band..... | λ613—593 |
| 2nd „ ..... | λ569—563 |
| 3rd „ ..... | λ556—551 |

No. 3. A similar spectrum from the pancreas of a cat :—

| | |
|---|---|
| 1st Band..... | λ613—596·5 |
| 2nd „ ..... | λ569—563 |
| 3rd „ ..... | λ556—548·5 |

No. 4. A myohæmatin spectrum from *Hydrophilus* :—

| | |
|---|---|
| 1st Band..... | λ613—593 |
| 2nd „ ..... | λ569—563 |
| 3rd „ ..... | λ557—548·5 |

No. 5. A myohæmatin spectrum from the heart of the lobster (*Homarus vulgaris*) :—

| | |
|---|---|
| 1st Band..... | λ613—593 |
| 2nd „ ..... | λ569—563 |
| 3rd „ ..... | λ556—550 |

No. 6. A myohæmatin spectrum from the heart of a cat :—

| | |
|---|---|
| 1st Band..... | λ613—596·5 |
| 2nd „ ..... | λ569—563 |
| 3rd „ ..... | λ556—550 |

It may be added that it is very difficult to measure these bands, and allowing for this fact the agreement is very close, especially as all the measurements were made independently of each other. It is also necessary to add that the above are what may be called typical histohæmatin spectra, as in some cases Bands 2 and 3 are joined to each other to form one band.